Application of MODIS-Terra cross-calibration for ocean color bands

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MCST

Measured TOA MODIS total signal

$$L_m(\lambda) = M_{11}L_t(\lambda) + M_{12}Q_t(\lambda) + M_{13}U_t(\lambda)$$

Mueller matrix

Stokes vector exiting TOA

$$\begin{bmatrix} L_m \\ Q_m \\ U_m \\ 0 \end{bmatrix} = \begin{bmatrix} M_{11} & M_{12} & M_{13} & M_{14} \\ M_{21} & \cdots & & M_{24} \\ M_{31} & \cdots & & M_{34} \\ M_{41} & M_{42} & M_{43} & M_{44} \end{bmatrix} \cdot \begin{bmatrix} L_t \\ Q_t \\ U_t \\ 0 \end{bmatrix}$$

Measured TOA MODIS total signal

$$L_m(\lambda) = M_{11}L_t(\lambda) + M_{12}[\, Q_t(\lambda)\cos 2\alpha + U_t(\lambda)\sin 2\alpha] + M_{13}[-Q_t(\lambda)\sin 2\alpha + U_t(\lambda)\cos 2\alpha]$$

Mueller matrix

Rotation matrix

Stokes vector exiting TOA

$$\begin{bmatrix} L_m \\ Q_m \\ U_m \\ 0 \end{bmatrix} = \begin{bmatrix} M_{11} & M_{12} & M_{13} & M_{14} \\ M_{21} & \cdots & & M_{24} \\ M_{31} & \cdots & & M_{34} \\ M_{41} & M_{42} & M_{43} & M_{44} \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos 2\alpha & \sin 2\alpha & 0 \\ 0 & -\sin 2\alpha & \cos 2\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} L_t \\ Q_t \\ U_t \\ 0 \end{bmatrix}$$

Rotation matrix (angle α)

α – rotation angle between

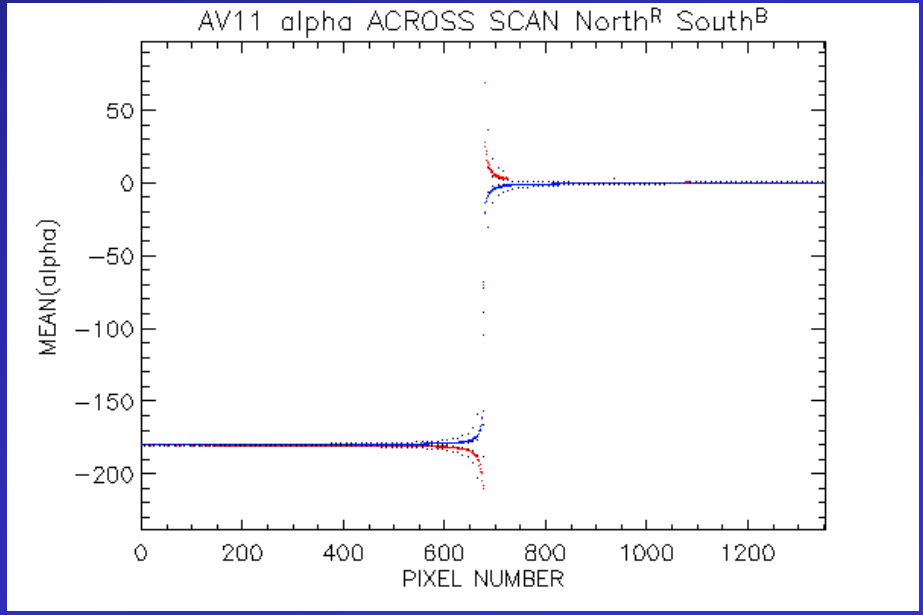
the reference plane determined by the propagation direction of the light and the vertical

and

the reference plane fixed with respect to the instrument

OBPG processing code l2gen

α is calculated using pixel lat, lon, and sensor geometry in l1_modis_hdf.c



Implementation of MODIS corrections

$$\frac{L_m}{M_{11}} = L_t + m_{12}[Q_t\cos 2\alpha + U_t\sin 2\alpha] + m_{13}[-Q_t\sin 2\alpha + U_t\cos 2\alpha]$$

$m_{12} = M_{12} / M_{11}$

$m_{13} = M_{13} / M_{11}$

$L'_m = \frac{L_m}{M_{11}}$

$polcor = \frac{L'_m}{L_t}$

$$polcor = \frac{1}{1 - m_{12}[\frac{Q_t}{L'_m}\cos 2\alpha + \frac{U_t}{L'_m}\sin 2\alpha] - m_{13}[-\frac{Q_t}{L'_m}\sin 2\alpha + \frac{U_t}{L'_m}\cos 2\alpha]}$$

OBPG processing code l2gen

M_{11} correction is applied to L_m in loadl1.c

polcor is calculated and applied in polcor.c

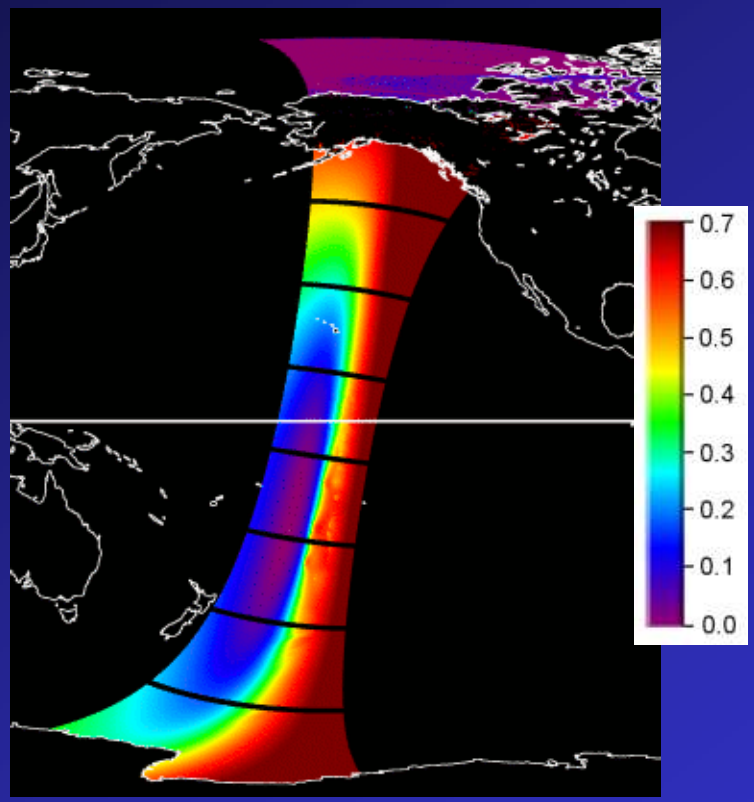
Radiative transfer modeling of the polarization of the atmosphere Q_t and U_t

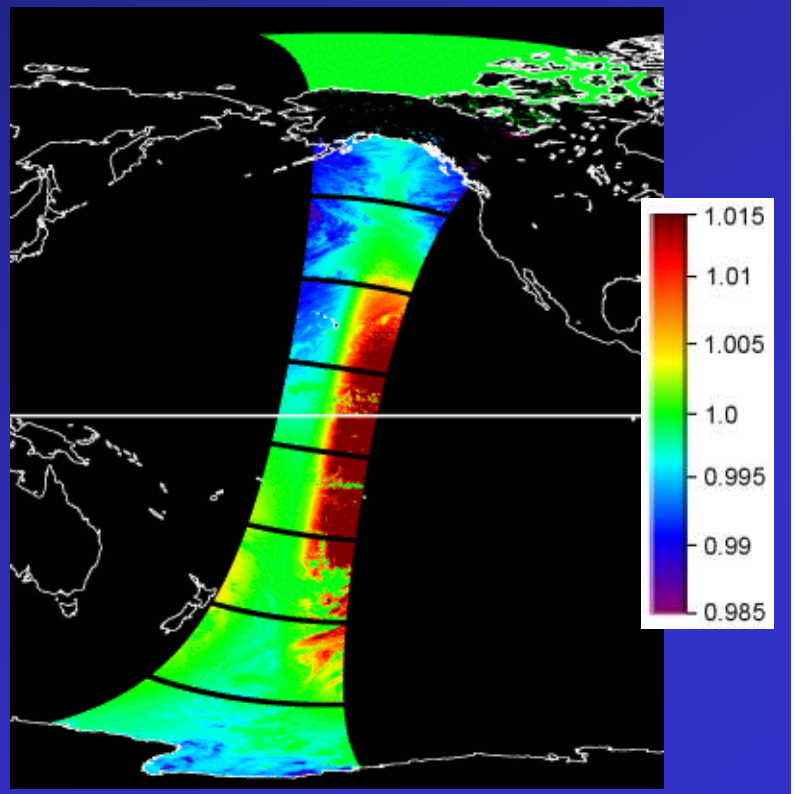
degree of atmospheric polarization (d_p)
air molecule (Rayleigh) and glint scattering

polarization correction (polcor)
pre-launch MODIS characterization

MODIS Terra swath

412nm band 8





$$d_p = \frac{\sqrt{Q_t^2 + U_t^2}}{L_t}$$

$$polcor = \frac{L'_m}{L_t}$$

OBPG MODIS-Terra corrections

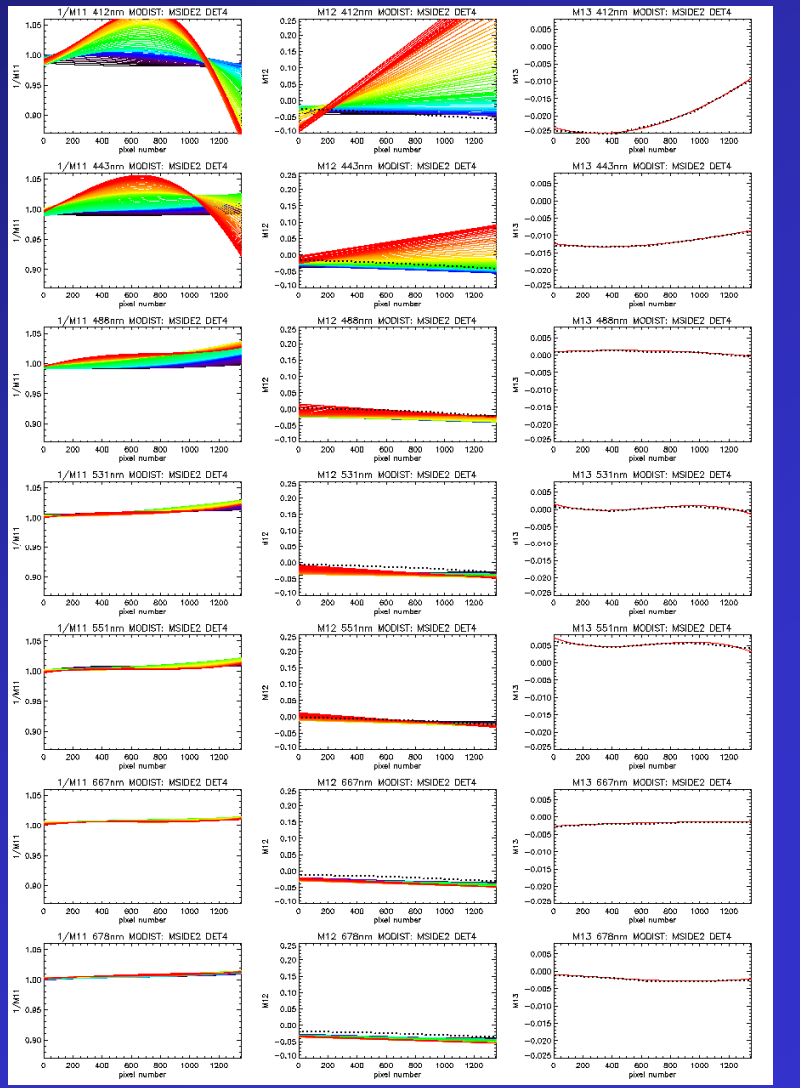
M_{11}, m_{12}, and m_{13} are currently available for ocean color 1km visible bands 8-14 only

Corrections for near-infrared bands 15 and 16 are investigated

m_{13} is used at its pre-launch value

M_{11}, m_{12} and m_{13} are represented as 3rd degree polynomials of pixel number (0-1353)

Corrections are provided per mirror side, detector, and in monthly intervals throughout the Terra lifetime



OBPG MODIS-Terra correction HDF table

netcdf xcal_modist_rvs_m12_m13 {
dimensions:

nwave = 9 ;
ndates = 200 ;
dp = 4 ;
ndets = 10 ;
nmirror = 2 ;

variables:

float wave(nwave) ;
wave:long_name = "wavelengths" ;
wave:units = "nm" ;
short year(ndates) ;
year:long_name = "year in the time series" ;
year:units = "dimensionless" ;
short day(ndates) ;
day:long_name = "days of the year in the time series" ;
day:units = "dimensionless" ;
double M11(dp, ndets, nmirror, nwave, ndates) ;
M11:long_name = "M11 polynomial coefficients of pixel number (RVS and temporal trend)" ;
M11:units = "dimensionless" ;
double m12(dp, ndets, nmirror, nwave, ndates) ;
m12:long_name = “m12=M12/M11 polynomial coefficients of pixel number (polarization sensitivity, Qt)" ;
m12:units = "dimensionless" ;
double m13(dp, ndets, nmirror, nwave, ndates) ;
m13:long_name = " m13=M13/M11 polynomial coefficients of pixel number (polarization sensitivity, Ut)" ;
m13:units = "dimensionless" ;

OBPG MODIS-Terra correction recommendations

M_{11} is derived relative to an MCST LUT. L1B processing should apply the same LUT. The LUT version is an attribute in the HDF correction file

M_{12} and M_{13} are derived at their absolute value. They are normalized by M_{11} to relate to the polarization sensitivity of a calibrated instrument

For corrections of Terra ocean color bands in between the days in the time series, linear interpolation of neighboring day corrections should be applied

For corrections of days beyond the limits of the time series, constant first or last available correction is recommended